

PROPERTIES AND ENVIRONMENTAL IMPACT FROM MOSAIC SLUDGE
INDUSTRY INCORPORATED INTO FIRED CLAY BRICKS

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*To my loving family and friends
My love to you all will always remain...*



PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

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ABSTRACT

Brick is one of the most common masonry units used as building material. Due to the demand recently, different types of waste materials have been investigated to be incorporated into bricks. The utilization of these waste materials in fired clay bricks usually has positive effects on the properties such as lightweight bricks with improved shrinkage, porosity, and strength. The main objective of this study is to focus on the properties and environmental impact of the mosaic sludge incorporated into fired clay bricks. The characteristics of raw materials obtained by using the X-Ray Fluorescence Spectrometer showed that the chemical composition of the raw materials of clay soil and mosaic sludge was high with silicon dioxide and aluminium oxide and with the same chemical composition BS and PS are suitable to replace clay soil as raw materials. The recommended percentage of BS and PS incorporation was up to 30% with better physical and mechanical properties. The results showed that the utilization of BS and PS brick obtained higher compressive strength up to 25 N/mm² and low initial rate of suction under the limit of 5 g/mm². The leachability tests such as Toxicity Characteristic Leaching Procedure (TCLP), Synthetic Precipitation Leaching Procedure (SPLP) and Static Leachate Procedure (SLT) were conducted to determine the results which complied with the United State Environment Protection Agency (USEPA) and Environment Protection Agency Victoria (EPAV). As for the indoor air quality, BS sludge and PS sludge could be incorporated up to 30% in the fired clay bricks for good physical and mechanical properties that complied standard requirements for heavy metals with better indoor air quality based on the Industry Codes of Practice on Indoor Air Quality (ICOP-IAQ) standards. Therefore, BS and PS wastes can be an alternative low cost material that provides an environmentally friendly disposal method.

ABSTRAK

Bata merupakan satu unit masonri yang biasa digunakan sebagai bahan binaan. Berdasarkan permintaan, beberapa jenis sisa yang berbeza telah dikaji dan dimasukkan ke dalam batu bata. Penggunaan sisa ini di dalam bata tanah liat kebiasaannya mempunyai kesan yang positif terhadap sifatnya seperti batu-bata ringan yang diperbaiki dari segi penyusutan, keliangan, dan kekuatan. Objektif utama kajian ini untuk memfokuskan ciri-ciri dan kesan terhadap alam sekitar dengan menggunakan sisa *Bodymill Sludge* (BS) dan *Polishing Sludge* (PS) ke dalam bata tanah liat. Ciri-ciri yang telah diperoleh dengan menggunakan Spektrometer Pendarfluor Sinar-X (XRF) menunjukkan komposisi kimia bahan mentah daripada tanah liat dan enap cemar mozek mengandungi silikon dioksida dan aluminium oksida yang tinggi dengan komposisi ciri yang sama BS dan PS sesuai menggantikan tanah liat sebagai bahan mentah. Peratusan PS dan BS yang disyorkan sehingga 30% dengan sifat fizikal dan mekanikal yang lebih baik. Penggunaan enap cemar sepenuhnya daripada bata BS dan PS memperolehi kekuatan mampatan yang paling tinggi dengan 25 N/mm² dan kadar awal ujian sedutan dibawah had 5 g/mm². Semua ujian pengurusan untuk Prosedur Pengurusan Ciri Ketoksikan (TCLP), Prosedur Pengurusan Hujan Tiruan (SPLP) dan Ujian Pengurusan Statik (SLT) ditentukan dan secara amnya mematuhi Agensi Perlindungan Alam Sekitar Amerika Syarikat (USEPA) dan Agensi Perlindungan Alam Sekitar Victoria (EPAV). Sementara itu kualiti udara dalaman, enapcemar BS dan enapcemar PS boleh digunakan sehingga 30% di dalam bata tanah liat kerana sifat fizikal dan mekanikal yang baik yang mematuhi piawaian bagi logam berat dan dengan kualiti udara dalaman yang lebih baik berdasarkan piawaian Kod Amalan Industri Kualiti Udara Dalaman (ICOP-IAQ). Oleh itu, enap cemar BS dan enap cemar PS boleh menjadi alternatif sebagai bahan berkos rendah dalam menyediakan kaedah pelupusan yang mesra alam sekitar.

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LIST OF SYMBOLS AND ABBREVIATIONS

%	- Percent
\leq	- Less-than or Equal to
\geq	- Greater-than or Equal to
$^{\circ}\text{C}$	- Degree Celsius
$^{\circ}\text{C}/\text{min}$	- Degree Celsius per minute
μ	- micro
μm	- Micro meter
A	- Area
AAS	- Atomic Absorption Spectroscopy
Al	- Aluminium
Al_2O_3	- Aluminum oxide
As	- Arsenic
Ba	- Barium
BS	- Bodymill Sludge
C	- Ceiling limit
CaO	- Calcium oxide
Cd	- Cadmium
Ce	- Cerium
Cfu/m^3	- Colony Forming Unit per Cubic Meter

cm^3	- Cubic centimeter
CO	- Carbon Monoxide
Co	- Cobalt
CO_2	- Carbon Dioxide
Cr	- Chromium
Cs	- Cesium
Cu	- Copper
CuO	- Copper(II) oxide
D	- Diameter
EN	- European Standard
EPA	- Environmental Protection Agency
EPAV	- Environmental Protection Agency Victoria
ER	- Empty Room
et al	- And others
Fe	- Ferum
Fe_2O_3	- Ferric oxide
FKAAS	- Fakulti Kejuruteraan awam dan alam sekitar
g	- Gram
g/cm^3	- Gram per cubic meter
Ga	- Gallium
HCHO	- Formaldehyde
IAQ	- Indoor Air Quality
ICOP-IAQ	- Industry Code of Practice on Indoor Air Quality
ISO	- International Organization for Standardization
K_2O	- Potassium oxide
kg	- Kilogram
kg/m^3	- Kilogram per cubic meter



kN	- Kilo newton
L	- Length
L/min	- Liter per minute
La	- Lanthanum
LL	- Liquid Limit
LLD	- Lower Level Detection
LOI	- Loss on Ignition
Ls	- Actual Length – Dry Length
L _{wet}	- Wet Length
L _{dry}	- Dry Length
M	- mass
M1	- Dry Mass
m1	- Mass of wet brick
M2	- Wet Mass
m2	- Submerged mass of brick
mg/L	- Milligram per litre
mg/m ³	- Milligram per cubic meter
MgO	- Magnesium oxide
mm	- milimeter
MMB	- Malaysia Mosaic Berhad
Mn	- Mangan
MnO	- Manganese(II) oxide
mo	- Ambient mass
Mo	- Molybderium
MPa	- Megapascal
N/mm ²	- Newton per millimeter square
NA	- Not Available

Na ₂ O	- Sodium oxide
Nb	- Niobium
ND	- Not Detectable
Ni	- Nickel
O ³	- Ozone
OMC	- Optimum Moisture Content
P ₂ O ₅	- Phosphorus pentoxid
Pb	- Lead
PI	- Plasticity Index
PL	- Plastic Limit
PM ₁₀	- Particulate Matter
ppm	- part per million
PS	- Polishing Sludge
psi	- Pounds per square inch
Rb	- Rubidium
RECESS	- Research Centre for Soft Soil
RH	- Relative humidity
Sb	- Antimony
Sc	- Scandium
SEM	- Scanning Electron Microscope
SiO ₂	- Silicon dioxide
SLT	- Static Leachate Test
Sn	- Tin
SO ₃	- Sulphur trioxide
SPLP	- Synthetic Precipitation Leaching Procedure
Sr	- Strontium
SrO	- Strontium oxide

TCLP	- Toxicity Characteristic Leaching Procedure
TEL	- Thermal Environmental Laboratory
Th	- Thorium
Ti	- Thallium
TiO ₂	- Titanium dioxide
TVOC	- Total volatile organic compounds
twa	- time-weighted average
U	- Uranium
USEPA	- United States Environmental Protection Agency
UTHM	- Universiti Tun Hussein Onn Malaysia
V	- Vanadium
VOCs	- Volatile organic compound
WHO	- World Health Organization
WiSC	- Walk in Stability Chamber
wt.	- Weight
XRF	- X-Ray Fluorescence
Y	- Yttrium
Zn	- Zinc
ZnO	- Zinc oxide
Zr	- Zirconium
ZrO ₂	- Zirconium dioxide
ΔT	- temperature gradient
ρ	- Density
π	- Pi



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